Rejections Under 35 U.S.C. 103(a)

Claims 1-8, 11-17, 23-26 are rejected under 35 U.S.C. §103(a) as being unpatentable over Pelrine et al. "Electrostriction of Polymer Films for Microactuators" for the explicit reasons set forth in paper no. 14 (dated June 20, 2002). Applicants respectfully traverse.

In this paper, the examiner states the reference discloses in figs. IV and V a transducer comprising two electrodes and a pre-strained polymer. The examiner also states the reference does not disclose the same maximum strain or the same pre-strain as the present invention. The reference does disclose the relationship between the pre-strain and the strain. The court has stated that where the general conditions of a claim are disclosed in the prior art, it is not inventive to discover the optimum or workable ranges by routine experimentation. It would have been obvious to one of ordinary skill in the art to optimize the pre-strain for the purpose of obtaining the desired strain.

First, examiner has stated the reference discloses the relationship between the pre-strain and the strain. The examiner does not cite a location in the reference and it is not clear to the applicant what the Examiner is describing. Applicant respectfully requests the Examiner to point out the location in the reference the Examiner where the relationship is taught and what the Examiner is describing as it pertains to the current invention.

The reference teaches in regards to FIG. 2 (see page 13) that the simplest actuators are a stretched film. In FIG. 3, the relationship between strain and electric field is shown for a silicone film. The maximum strain shown in the FIG. 2 is about .2. The reference clearly describes maximum material limits for a number of different materials that are below the ranges of the current invention. Table 1 shows that the highest strain performance for a material tested (Dow Corning) was 32% (Page 9, under Performance of Electrostrictive Polymers) with other materials having a lower maximum strain performance. The maximum applied voltage at the maximum strain is also shown. Above the maximum voltage, the strain in the material will not increase. Thus, the reference does not suggest that the strain increases indefinitely as the voltage is applied.

In contrast, the present invention recites in claim 1, a transducer comprising "a polymer arranged in a manner which causes a portion of the polymer to deflect from a first position with a first area to a second position with a second area in response to a change in electric field, wherein

an initial area of the portion of the polymer is elastically pre-strained to the first area by a factor in the range of about 1.5 times to 50 times to improve the mechanical response of the transducer when it deflects from the first position to the second position." As noted by the examiner, these ranges are not taught in cited prior art reference. It was discovered in the present invention that elastically pre-straining the polymer prior to deflection via the electric field can significantly improve the mechanical response of the polymer when an electric field is applied. This effect is not described in the prior art. Prior to the present invention, it was not expected that an elastic strain i.e., a stretch below the yield limit of the polymer such that the material approximately returns to its originally shape after the strain is removed, would affect the mechanical response of the polymer. For example, in one embodiment of the present invention, the dielectric constant of the polymer is altered as the result of an elastic pre-strain.

The examiner has stated that that the effect of pre-strain described in claim 1 is obvious. The applicant submits that the elastic pre-strain effects were not recognized in the prior art and these are unexpected results. As evidence to this fact, the unexpected results of elastic pre-strain on the polymer performance were recognized in the journal *Science*. The examiner states that Piezo-electric polymers are routinely stretched at least 2-3 times their original lengths during the polarizing/orientation stages of manufacture and that Scheinbeim, Lemonon and Raviner all of record show stretching of polymers to make them active and increase efficiency. Applicant asks is the Examiner describing elastic stretching? Applicant believes the Examiner is referring to a process where the polymer is stretched beyond its yield limit producing permanent deformation of the material. Therefore, because the effects of elastic pre-strain on polymer performance are an unexpected result, the prior art can't be said to render obvious the invention as recited in claim 1.

The present invention, as described in Claim 24 for instance, recites a transducer comprising "a polymer arranged in a manner which causes a portion of the polymer to deflect from a first position with a first length to a second position with a second length in response to a change in electric field provided by the at least two electrodes, wherein the portion deflects with a linear strain between about 50 percent and about 215 percent between the first length and the second length in response to the change in electric field." The ranges in claim 24 are well beyond the maximum strains predicted in the reference cited by the prior art reference (see Table 1). The reference does not teach or suggest linear strains during deflection between about 50% and 215% as the suggested

maximum strain is only about 32% and for many of the materials the maximum strain is much less than this value. The reference clearly teaches that for the polymers tested there is a maximum strain beyond which the application of a voltage does not produce any additional strain in the material. Thus, for at least these reasons, the prior art reference can't be said to render obvious the invention as recited in claim 24. If the Examiner sees an obvious method of experimentation that is taught or suggested in the reference that would lead to the linear strain ranges as recited in claim 24, the applicant requests the Examiner to clearly specify a method of modification from the reference or from a combination of the reference and what is known in the art and the desirability of said method of modification from what is taught or suggested in the reference or from what is known in the prior art.

Since all pending claims include either the limitations of claim 1 and 24 and the references can't be said to render obvious claims 1 and 24, applicant believes all claims are in condition for allowance and withdrawal of the rejections under 35 USC §103(a) is therefore respectfully requested.

Conclusion

In view of the foregoing, Applicant believes that all pending claims are allowable and respectfully request a Notice of Allowance from the Examiner. Should the Examiner believe that a telephone conference would expedite the prosecution of this application, the undersigned can be reached at the number set out below. If any fees are due in connection with the filing of this paper, the Commissioner is authorized to charge such fees to Deposit Account 50-0388 (Order No. SRI1P020).

Respectfully submitted,
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APPENDIX A

VERSION WITH MARKINGS TO SHOW CHANGES MADE

1. (Twice Amended) A transducer for converting from electrical energy to mechanical energy, the transducer comprising:

at least two electrodes; and

a polymer arranged in a manner which causes a portion of the polymer to deflect <u>from a first position with a first area to a second position with a second area</u> in response to a change in electric field, wherein [a] <u>an initial area of the</u> portion of the polymer is elastically pre-strained <u>to the first area</u> by a factor in the range of about 1.5 times to 50 times [the original area] <u>to improve the mechanical response of the transducer when it deflects from the first position to the second position</u>.

24. (Amended) A transducer for converting electrical energy to mechanical energy, the transducer comprising:

at least two electrodes; and

a polymer arranged in a manner which causes a portion of the polymer to deflect <u>from a first position with a first length to a second position with a second length</u> in response to a change in electric field provided by the at least two electrodes, wherein the portion deflects with a [maximum] linear strain between about 50 percent and about 215 percent <u>between the first length and the second length</u> in response to the change in electric field.

APPENDIX B OF PENDING CLAIMS

1. (Twice Amended) A transducer for converting from electrical energy to mechanical energy, the transducer comprising:

at least two electrodes; and

a polymer arranged in a manner which causes a portion of the polymer to deflect from a first position with a first area to a second position with a second area in response to a change in electric field, wherein an initial area of the portion of the polymer is elastically pre-strained to the first area by a factor in the range of about 1.5 times to 50 times to improve the mechanical response of the transducer when it deflects from the first position to the second position..

2. The transducer of claim 1 wherein the transducer has a maximum linear strain of at least about 50 percent in response to the change in electric field.

3. The transducer of claim 1 wherein the transducer has a maximum linear strain of at least about 100 percent in response to the change in electric field.

4. The transducer of claim 1 wherein the transducer has a maximum area strain of at least about 100 percent in response to the change in electric field.

5. The transducer of claim 1 wherein the pre-strain is applied to a first orthogonal direction at a pre-strain greater than pre-strain in a second orthogonal direction.

6. The transducer of claim 5 wherein the pre-strain applied to the first orthogonal direction is used to enhance deflection in the second orthogonal direction.

7. (Once Amended) The transducer of claim 6 wherein the polymer has a dielectric constant between about 2 and about 20.

8. The transducer of claim 1 wherein the polymer comprises one of a silicone rubber and an acrylic.

9. The transducer of claim 1 further comprising a barrier layer.

10. The transducer of claim 1 wherein the polymer comprises a textured surface.

11. The transducer of claim 1 wherein the polymer has a thickness between about 1 micrometer and 2 millimeters.

12. The transducer of claim 1 wherein the polymer is one of a commercially available silicone elastomer, polyurethane, PVDF copolymer or adhesive elastomer.

13. The transducer of claim 1 wherein the change in electric field is at most about 440 MegaVolts/meter.

14. The transducer of claim 1 wherein the polymer has a maximum actuation pressure between about 0.1 Pa and about 10 MPa.

15. The transducer of claim 1 wherein the polymer has an operational frequency less than about 100 kHz.

16. The transducer of claim 1 wherein the polymer has an elastic modulus below about 100 MPa.

17. The transducer of claim 1 wherein the portion of the polymer deflects out of the plane of the polymer in response to the change in electric field.

18. The transducer of claim 1 further comprising a stiff member attached to a portion of the polymer.

19. The transducer of claim 18 wherein the stiff member is included in a frame.

20. The transducer of claim 1 wherein one of the at least two electrodes is compliant.

21. The transducer of claim 1 further comprising a second polymer arranged in a manner which causes a portion of the second polymer to deflect in response to a second change in electric field and the second polymer is coupled to the first pre-strained polymer.

22. The transducer of claim 21 wherein the second polymer is mechanically coupled to the first polymer such that they have the same deflection.

23. The transducer of claim 1 wherein the transducer is included in an artificial muscle.

24. (Amended) A transducer for converting electrical energy to mechanical energy, the transducer comprising:

at least two electrodes; and

a polymer arranged in a manner which causes a portion of the polymer to deflect from a first position with a first length to a second position with a second length in response to a change in electric field provided by the at least two electrodes, wherein the portion deflects with a linear strain between about 50 percent and about 215 percent between the first length and the second length in response to the change in electric field.

25. The transducer of claim 24 wherein the polymer comprises one of a silicone rubber and an acrylic.

26. The transducer of claim 24 wherein the polymer is one of a commercially available silicone elastomer, polyurethane, PVDF copolymer or adhesive elastomer.

27-52. Withdrawn from Consideration.

53. The transducer of claim 24 wherein the polymer has a dielectric constant between about 2 and about 20.

54. The transducer of claim 24 wherein the polymer comprises one of a silicone rubber and an acrylic.

55. The transducer of claim 24 wherein the polymer has a thickness between about 1 micrometer and 2 millimeters.

56. The transducer of claim 24 wherein the polymer has an elastic modulus below about 100 MPa.

57. The transducer of claim 24 wherein the portion of the polymer deflects out of the plane of the polymer in response to the change in electric field.

58. The transducer of claim 24 further comprising a stiff member attached to a portion of the polymer.

59. The transducer of claim 24 wherein the transducer is included in an artificial muscle.